IMAGE PRODUCTION AND EVALUATION

10 REASONS TO FAILURE

1. Poor people skill
2. A negative attitude
3. A bad fit
4. Lack of focus
5. A weak commitment
6. An unwillingness to change
7. A shortcut mind set
8. Relying on talent alone
9. A response to poor information
10. No goals

RADIATION TECHNIQUE

DARKROOM

- A scientific laboratory
- Where radiography starts and ends

OCCUPATIONAL SAFETY AND HEALTH AGENCY (OSHA)

- It requires RT to wear face mask
- RATIONALE: fumes are carcinogenic

DARKROOM DISEASE

- Hypersensitivity to fumes

MAIN FUNCTION OF DARKROOM

- To prevent/protect film from exposure to white light and ionizing radiation during handling and processing

EXPOSED FILM

- 2-8 times more sensitive to subsequent exposure than unexposed film
- **RATIONALE:** it contains the latent image

LATENSIFICATION

- Increase in sensitivity after exposure to white light or ionizing radiation

IMPORTANCE OF PROCESSING ROOM

1.) LOCATION

- In proximity/near to exposure room

2.) SIZE

- 15ft x 9.5 ft or greater
- 200 radiographs/day

Wet and Dry Section

- 4 ft away from each other
- To prevent contamination of the dry section

3.) PROTECTS AGAINST RADIATION

- Darkroom can be adjacent to exposure room only if:
  - **CONCRETE:** greater than 6 inches
  - **HOLLOW BLOCKS:** filled with cement
  - **WOOD:** with 1.5 mm Pb

AUTOMATIC PROCESSOR

(24 inches/corner)

A.) TOTALLY INSIDE

- All automatic processor are located inside
- **ADVANTAGE:** jammed films can be retrieved without exposure to white light
- **DISADVANTAGES:**
  - Increased heat/temperature, noise and humidity/moist

B.) BULK INSIDE

- All automatic processor are located inside but the drop tray is located outside
- More advisable
- **ADVANTAGES:**
  - Easy retrieval of films
  - Decreased heat/temperature, noise and humidity/moist

C.) BULK OUTSIDE

- Only the feed tray is located inside
- Used only when the darkroom is small

- **ADVANTAGES:** almost no heat, noise and humidity
- **DISADVANTAGES:**
    - Jammed films can't be retrieved through white light
    - Repeat exposure when the films are exposed

4.) VENTILLATION

- **AIR CHANGES:**
    - 8-10 per hour
    - Exhaust fan
- **AIR MOVEMENT:**
    - Air inside the darkroom
    - 15-25 ft/min
    - Fan
- **STORAGE ROOM TEMPERATURE:**
    - 10-21 ^{o}C/50-70 ^{o}F
- **DARKROOM TEMPERATURE:**
    - 20 ^{o}C/67-83 ^{o}F (OLD)
    - 18-24 ^{o}C/65-85 ^{o}F (NEW)
- **HUMIDITY FOR STORAGE ROOM AND DARKROOM:**
    - 40-60%
    - 30-60% (NEW FOR DR)

PSYCHROMETER

- A device used to measure humidity or moisture

HYGROMETER

- A device used to measure environmental moisture

5.) CLEANLINESS

- Avoid SMOKING, EATING and DRINKING
- **RATIONALE:** to prevent artifacts

EFFICIENT DARKROOM

- Pertaining to cleanliness
- Uncluttered counter tops

6.) LIGHT-TIGHT ENTRANCE

- **SINGLE DOOR DARKROOM**
    - The simplest type
    - Need to provide a passbox
    - **RATIONALE:** avoid RT in entering the darkroom
- **LIGHT-LOCK DOOR/DOUBLE DOOR DARKROOM**
    - Used only when there is darkroom personnel exclusive in the darkroom
    - If door 1 is open, door 2 is closed
- **LABYRINTH/MAZE**
    - Zigzag type
    - Used only when the darkroom is large
    - **RATIONALE:** it requires more space
- **REVOLVING DOOR**
    - The fast access type
    - RATIONALE: can enter and exit at the same time

PASSBOX/FILM CASSETTE TRANSFER CABINET

- Allows the film to transfer without entering the darkroom
- Has an interlocking/alarm

7.) ILLUMINATION

- **WHITE LIGHT ILLUMINATION**
    - Overhead light
    - 2-4 fluorescent lamps
    - 48 inches/8 m^2
    - PURPOSE:
        - Maintenance
        - Emergency cases
        - Cleaning

IMAGE PRODUCTION AND EVALUATION

- **SAFELIGHT ILLUMINATION**
    - **DISTANCE:** 3-4 ft
    - **WATTAGE:**
        - 7.5 watts (3 ft distance)
        - 15 watts (4 ft distance)
    - **FILTERS:**
        - Filters out intensity (strength) and energy (color)
    - **AMBER FILTER**
        - Filters out Red, Orange and Yellow colors
        - **APPEARANCE:** brownish
        - For monochromatic film (blue-sensitive film)
    - **WRATTEN 6B FILTER**
        - Filters only the intensity
        - For monochromatic film (blue-sensitive film)
        - **ALTERNATIVES:** Amber filter & Kodak Mor-lite
    - **GBX 2 FILTER**
        - Filters out intensity and color (Yellow and Orange)
        - For orthochromatic film (blue/green sensitive film)
        - Multi-purpose filter
        - **APPEARANCE:** red color

PANCHROMATIC FILM

- Sensitive to all visible light spectrum
- **ADVANTAGE:** all kinds of film can be used
- **DISADVANTAGE:** no safelight is used

CALCIUM TUNGSTATE

- For blue-sensitive film

RARE EARTH

- For green sensitive film

8.) COLORS OF WALL

- **PASTEL AND LIGHT:** reflectance of safelight
- **ENAMEL AND EPOXY:** easy to clean and durable
- **MATTE FINISH NOT GLOSSY:** it will not reflect white light
- **NEON COLOR:** prohibited
- **Bright Color vs Dark Color:** bright color is the best choice

9.) ELECTRICAL WIRING

- Should be appropriately installed

SAFELIGHT

- **DIRECT SAFELIGHT**
    - Fixture type safelight
    - Light is distributed directly
    - Most common in the hospital
- **INDIRECT SAFELIGHT**
    - Ceiling type safelight
    - Light goes up first, then reflected
    - BULB: Sodium vapor
    - **DISTANCE:** 6 ft
    - **DISADVANTAGE:** it takes time to warm up

QUALITY CONTROL FOR THE DARKROOM AND AUTOMATIC PROCESSOR

A.) DARKROOM ENVIRONMENT

- Daily
- Maintained clean, well ventilated, organized and safe

B.) SAFELIGHT TEST

- Semi-annual
- **SAFELIGHT FOG:** greater than 0.05 OD
    - Always check the DISTANCE, WATTAGE and FILTERS used
    - **WRATTEN 6B:** >550 nm
    - **GBX 2:** > 600 nm

  - **ACCEPTABLE:** 0.04 OD

C.) AUTOMATIC PROCESSOR TEMPERATURE

- Weekly
- Greater than $\pm 0.3\ ^{o}C/0.5\ ^{o}F$

D.) REPLENISHMENT RATE

  - Weekly
  - Within ±5%

OXIDIZED DEVELOPER

- Old or exhausted developer
- Reducing capacity has been reduced
- Decreased the activity of developer, activator/buffer, preservative except for restrainer
- All solution should be replaced except for restrainer

RESTRAINER

- Controls the activity of the developing agent

CONTAMINATED SOLUTION

- Entire solution is ineffective
- Can't be replenished
- Should be replaced

FUNCTION OF REPLENISHMENT RATE

- Maintain or bring back the activity of chemical on its original activity or composition

E.) DEVELOPER SOLUTION pH

- Quarterly/Every 3 months/Weekly
- **NORMAL pH:** 10-11.5 or 9.6-10.6
- **ALKALINIZER:** Sodium hydroxide and Sodium carbonate

F.) FIXER SOLUTION

- Quarterly/Every 3 months/Weekly
- **NORMAL pH:** 4-4.5 or 4.2-4.9
- **ACIDIFIER:** Acetic acid and Sulfuric acid

pH RANGE

- **7-14:** alkaline, base chemical
- **7:** neutral, water
- **0-7:** acid, acidic chemical

G.) DEVELOPER SPECIFIC GRAVITY

- Quarterly/Every 3 months/Weekly
- Not greater than 0.004

SPECIFIC GRAVITY

- The amount of water versus chemical

HYDROMETER

- A device that measures specific gravity

H.) PROCESSOR CONTROL CHART MONITORING

- Daily
- Early in the morning
- After the automatic processor reached its maximum capacity or has been warmed up
- Not greater than 0.15 OD from baseline measurements
- Speed and contrast indication

FILM SENSITOMETRY

- Quantitative measurement of response of film to exposure and development
- **DEVICES USED:**
  - **Sensitometer:** optical step wedge
  - **Penetrometer:**
    - Aluminum step wedge
    - Alternative for sensitometer
  - **Densitometer:** measures the density of exposed film
  - Step Table
  - Sensitometric strips

- **CONTROLS:**
  - Film speed
  - Film contrast
  - Film latitude
  - Contrast using hydroquinone

POWER OF HYDROGEN (pH)
- Qualitative method of measuring the alkalinity or acidity of the solution

PHENIDONE
- Film speed indicator
- First to produced
- Gray shade
- D_{min} = 1.2
- Controls the toe of the characteristic curve

HYDROQUINONE
- Film contrast indicator
- Second to produced
- Black tones
- D_{max} = greater than 1.2
- Controls the shoulder of the characteristic curve

HISTORICAL BITS

1895 – photographic plates
1914 – cellulose nitrate film base
1918 – duplitized films
1924 – cellulose triacetate film base
1933 – tinted film base
1936 – direct film exposure
1940 – film suitable for both direct & indirect exposure
1958 – fast light-sensitive film
1960's – polyester film base and film for rapid processing

FILM BASE
- Foundation of the radiographic film

ARCHIVAL QUALITY
- Permanence of the image

INTENSIFYING SCREEN
- 15-20 times less radiation
- Used since beginning
- **BASE:** cardboard and high quality plastic (polyester)
- **ADVANTAGES:**
  - Reduces radiation dose
  - Decreases technical factors
- **DISADVANTAGES:**
  - Increased quantum mottle
  - Blurred image

NO INTENSIFYING SCREEN
- **ADVANTAGE:** No quantum mottle
- **DISADVANTAGE:** Increases patient dose

REMNANT RADIATION
- Radiation that is not absorb by the patient and form the latent image

DUPLITIZED FILM
- Double emulsion film
- **ADVANTAGES:**
  - Double the film speed
  - Decreases patient dose
- **DISADVANTAGE:**
  - Parallax effect/crossover

FACTORS THAT AFFECT FILM SPEED
- Number and size of silver halide crystals

TINTED FILM BASE
- Decreases the possibility of parallax effect/crossover
- Reduces eye fatigue and eye strain
- Increases contrast under the negatoscope

IMAGE PRODUCTION AND EVALUATION

FAST LIGHT SENSITIVE FILM

- Decrease X-ray – Increase Film Speed
- Increase Patient Dose – Increase Image Quality – Decrease Parallax Effect
- Decrease Patient Dose – Decrease Image Quality – Increase Parallax Effect

PATIENT DOSE

- Directly proportional to the image quality
- Increase IS Speed – Decrease Patient Dose – Decrease Image Quality – Increase Quantum Mottle

GRID

- To improve image contrast
- Increase Grid Ratio – Decrease Scattered Radiation – Decrease Fog – Decrease Density – Increase mAs
- **DISADVANTAGE:** increase patient dose

AUTOMATIC PROCESSOR

1942

- PAKO
- 1st automatic processor
- Specialized hanger

1956

- EASTMAN
- Roller transport system

1965

- 1st rapid processing
- 90 secs

1987

- KONICA
- 45 secs
- Special chemicals

ELECTROMAGNETIC SPECTRUM VS VISIBLE SPECTRUM

ELECTROMAGNETIC SPECTRUM

- The range of frequencies over which an electromagnetic radiation can be propagated
- **Note:** x-ray films are more sensitive in visible light than x-rays

VISIBLE SPECTRUM

- The range of wavelength of the electromagnetic spectrum over which an unaided human eye can perceive changes as an alteration in color

SENSITIVITY

- Response of x-ray film to wavelengths of visible light

SPECTRAL SENSITIVITY

- The range of wavelength of the electromagnetic radiation that the film will respond

PEAK SENSITIVITY

- The range of wavelength in which the film will exhibit its highest response

CUT-OFF SENSITIVITY

- The range of wavelength in which the film is no longer sensitive

TYPES OF FILM ACCORDING TO SPECTRAL SENSITIVITY

1.) MONOCHROMATIC FILM

- **COLOR:** Blue sensitive
- **GRAINS:** Globular
- **SCREEN PHOSPHOR:** Calcium tungstate (not specific emission)
- Sensitive to spectrum wavelength of photons

IMAGE PRODUCTION AND EVALUATION

2.) ORTHOCHROMATIC

- **COLOR:** Green sensitive
- **GRAINS:** Tabular
- **SCREEN PHOSPHOR:** Rare Earth (specific emission)
- Sensitive to green light by rare earth

3.) PANCHROMATIC FILM

- Sensitive to all visible light spectrum

GRAIN TECHNOLOGY

1.) GLOBULAR GRAIN

- Spherical in shape
- Has bigger volume
- For blue-sensitive film

2.) TABULAR GRAIN

- Tabletop-like structure
- Provides bigger surface
- For green sensitive film

CALCIUM TUNGSTATE

- Broad band colors (Blue, Indigo, Violet)
- **LINE EMISSION:** not specific emission

RARE EARTH

- **OXYBROMIDE:** Blue
- **OXYSULFIDE:** Green
- **LANTHANUM:** Blue
- **LINE EMISSION:** specific emission

LANTHANIDE

- **ATOMIC #:** 57-71
- **Yttrium:** 39
- **Lanthanum:** 57
- **Gadolinium:** 64

GENERAL TYPES OF FILM

1.) DIRECT EXPOSURE/NON-SCREEN

- Uses thicker emulsion
- Outdated technology
- **ADVANTAGES:**
  - Decreased parallax effect/crossover
  - Decreased quantum mottle
  - Increases image quality
- **DISADVANTAGES:**
  - Increased patient dose
  - Increased development time
- **APPLICATION:**
  - Intraoral dental radiography

2.) SCREEN FILM

- Indirect exposure o
- Uses thinner emulsion
- More sensitive to light
  - Light: 90-99%
  - X-ray: 1-10%
- **ADVANTAGES:**
  - Decreased patient dose
  - Decreased developing time
- **DISADVANTAGES:**
  - Increased quantum mottle
  - Blurred image

CLASSIFICATION OF FILM ACCORDING TO USE

1.) MAMMOGRAPHIC FILM

- For breast examination
- Fine grains
- Single emulsion
- Greater detail
- High exposure dose
  - **RATIONALE:** high mAs
- Increased patient dose – Decreased parallax effect – Increased detail
- Increased IS speed – Decreased light emission – Decrease OD – Increased mAs

HIGH RESOLUTION INTENSIFYING SCREEN

- Slow speed

IMAGE PRODUCTION AND EVALUATION

2.) THERAPY LOCALIZATION FILM

- It serves as a guideline
- Wide range of exposures
- Direct exposure
- Fine grain
- **ADVANTAGE:** increase resolution
- **DISADVANTAGE:** radiation is continuously emitted

SIMULATOR

- It used in Cobalt 60

LETHAL DOSE

- Dose required to kill cancer cells

TOLERANCE DOSE

- It should be greater than lethal dose

TREATMENT FOR BREAST CANCER

- Surgery – mastectomy
- Radiation Therapy – regional
- Chemotherapy – metastases

PALLIATIVE TREATMENT

- Lengthening the life in short term basis

CURATIVE TREATMENT

- Lengthening of life in long term basis

3.) DENTAL X-RAY FILM

- Intraoral Film – for direct exposure
  - Peripheral Film
  - Bitewing/Interproximal
  - Occlusal Film
- Extraoral Film – for screen-film
  - Panoramic

4.) VIDEO FILM

- Single emulsion
- It uses multiformat camera and laser camera

5.) PHOTOFLUOROGRAPHIC

- Abreugraphy
- Manuel Diaz Abreu
- Single emulsion
- For chest x-ray examination
  - Mass CXR
  - PTB
  - Lung cancer
- Miniature fluorography

6.) CINE/ROLL FILM

- Single emulsion film
- With sprocket holes
- Movie film
- Angiographic film
- Cardiac catheterization
- Width – 16 mm & 35 mm
- Image – 7 x 10 mm & 24 x 35mm
- Uses tagaro viewer
- Frame Rate – 30-60 frames/sec
- 100-300 rolls
- Black and white
- 35% actual images

7.) SPOT FILM

- For special procedures
- Width – 100 mm
- Frame Rate – 10 frames/sec

8.) COPY/DUPLICATING FILM

- Reversal film
- Single emulsion
- It uses UV lamp and light
- Black light bulb

9.) DOSIMETER/PERSONNEL MONITORING FILM

- Measures radiation absorbed dose

THEMORLUMINESCENT DOSIMETER (TLD)

- Frequently used
- Monthly

- Lithium fluoride
- No dosimeter film

OPTICALLY-STIMULATED LUMINESCENCE (OSL)
- Monthly
- Aluminum oxide
- No dosimeter film

FILM BADGE
- It used dosimeter film
- Wear inside the apron

PEN DOSIMETER
- Daily exposures
- Reset

PHILIPPINE NUCLEAR RESEARCH INSTITUTE
- Where the record of exposure is submitted

10.) AUTOMATIC SERIAL CHANGER
- Serial radiography
- Angiography
- Special procedure
- Special protective coating
  - To prevent scratches

11.) INDUSTRIAL FILM
- Mega electron volts
- High energy/radiation radiography

12.) POLAROID
- Paper-based
- Thermal paper
- DSA and UTZ

13.) LASER FILM
- No darkroom, fixer and developing solution
- Laser printing
  - MRI
  - CT Scan
  - Digital Radiography
  - DSA
- Red – sensitivity
- Infrared light

FILM STORAGE AND HANDLING

1.) UNEXPOSED FILM
- Stored in original packaging
- **RATIONALE:** expiration date
- Expired Film – Decreased Sensitivity/Loss Speed – Increased mAs
- Age Fog/Expired Film – Loss Contrast – Poor Image Quality

2.) EXPIRED FILM
- Should be discarded
- Silver recovery
  - Fixer – 50% Ag
  - Film – 50% Ag

3.) ARCHIVAL FILM
- 5 years/10 years
- Can be sold

4.) SCRAP FILM/SPOILAGE
- 50% Ag recovery

5.) GREEN FILM
- The most precious in terms of Ag recovery
- 100% Ag recovery
- Ag remain intact

VERTICAL/EDGE/STRAIGHT/UPRIGHT
- Storage of film
- **RATIONALE:**
  - To prevent film to stick to one another
  - To prevent pressure artifacts

STORAGE TEMPERATURE
- 10-21 ^{o}C/50-70 ^{o}F
- 40-60% humidity

MAXIMUM STORAGE
- 30-45 days at 21 ^{o}C/70 ^{o}F

- Greater than 1 year at 10 $^oC/50\ ^oF$
- 0 ^oC – stop film aging process
  - Film can be used but should be warm up to room temperature at 35 $^oC/85\ ^oF$
- Increased Temperature – rapid aging process

ENVIRONMENT
- Very important to film

POSSIBLE CONSEQUENCES OF STORING UNEXPOSED FILM IN ENVIRONMENT WITH IMPROPER TEMPERATURE AND RELATIVE HUMIDITY
- **Temperature too high:** increased fog level
- **Temperature too low:** increased static discharges
- **Humidity too high:** increased fog level
- **Humidity too low:** increased static discharges

STATIC ARTIFACTS
- Positive artifacts (black)

NECKLACE
- Negative artifacts (white)

TEMPERATURE AND HUMIDITY
- Directly related
- Increased Temperature – Increased Heat Fog – Increased Possibility of Static Artifacts

PACKAGING OF FILM
- Photo-inert photoethylene bag or metal foil
  - **RATIONALE:** to protect film from moisture and light

FILM STORED
- Must be protected from:
  - Heat
  - Radiation
  - Chemical fumes
  - Pressure

EXPIRATION DATE
- Adhere First In First Out (FIFO)
- **RATIONALE:** to beat the expiration date

HANDLING OF FILM
- **AVOID:**
  - Hand cream
    - **RATIONALE:** finger print marks (negative density mark)
  - Rubber gloves
    - **RATIONALE:** static artifacts (positive density marks)
- Cotton gloves can be used

KINDS OF FOG THAT CAN AFFECT THE FILM

1.) AGE FOG – expired film

2.) CHEMICAL/DEVELOPMENT FOG
- Fumes
- Contaminated developer solution (0.1 of fixer)

DEVELOPER
- All or none phenomenon

RESTRAINER
- Prevents chemical fog
- Increased Restrainer Activity – Increased Etol, Metol, Phenidone and Hydroquinone
- **FUNCTIONS:**
  - Control
  - Restrain
  - Regulate
  - Prevent development fog

IMAGE PRODUCTION AND EVALUATION

3.) SAFELIGHT FOG

- Most common cause of fog

4.) HEAT FOG

- Increased Temperature – Increased Heat Fog

5.) SECONDARY RADIATION FOG

- Increased kVp – Increased Scattered Radiation – Increased Fog
- X-ray – polyenergetic heterogenous beam
- 20-150 energy/kVp
    - 20-70 – produces scatter radiation
    - 80-120 – remnant radiation

mAs

- Controls quantity, amount and number of x-rays

APPEARANCE OF FOG

- Gray shades

FACTORS THAT CONTROL SCATTER RADIATION

1.) kVp

- Increased kVp – Increased Scatter Radiation – Increased Fog – Increased Density

2.) PATIENT THICKNESS, SIZE AND DENSITY

- Increased Thickness, Size and Density – Increased Scatter Radiation

3.) BEAM-RESTRICTING DEVICE/ COLLIMATOR

- Increased Collimation – Decreased Scatter Radiation

PATIENT

- Main source of scatter radiation

FOG

- Non information image
- Unwanted/supplementary density
- Decreased kVp – Decreased Scatter Radiation – Decreased Fog – Decreased Density – Increased mAs

POSITIVE-DENSITY ARTIFACTS

- Before processing

NEGATIVE DENSITY ARTIFACTS

- During processing

SENSITIZED MARKS

- Development tank
- Wet pressure sensitation

RADIOGRAPHIC FILM

IMAGE FORMING X-RAYS

- Those that exit the patient and interact with the image receptor

EXIT BEAM

- The x-rays that remain as the useful beam exits the patient

IMAGE RECEPTOR

- The medium that converts the x-ray beam into a visible image

RADIOGRAPHIC FILM

- **Basic Parts:** base & emulsion
- **Other Parts:** adhesive layer & overcoat
- **Thickness:** 150-300 μm
- Manufactured in total darkness
- **Biggest Size:** 35 x 43 cm. or 14 x 17 in.
- **Smallest Size:** 20 x 25 cm. or 8 x 10 in.

PARTS OF RADIOGRAPHIC FILM

1.) TOPCOAT/SUPERCOAT/OVERCOAT

- A protective covering of gelatin that enclosed the emulsion
- **Composition:** made up of gelatin

- **Purpose:**
    - Prevent damage to sensitive emulsion layer
    - Protects the emulsion from scratches, pressure & contamination
    - Allows rough manipulation of x-ray film before exposure

2.) EMULSION

- The heart of the radiographic film
- Active layer
- Radiation and light sensitive
- **Size:** 3-5 or 10-20 micrometer
- **Composition:** silver halide crystal & gelatin
- **Silver Halide Crystal:** recording medium
    - The active ingredient of the emulsion
    - **Characteristic:** high atomic number (Z)
- **Composition:**
    - **Silver bromide:** 98% or 90-99%
    - **Silver iodide:** 2% or 1-10%
- **Shapes:** tabular (mostly used), cubic, octahedral, polyhedral & irregular
- **Gelatin:** mechanical binder
    - It holds the silver halide crystal uniformly dispersed in place
    - **Characteristics:** clear & sufficiently porous
    - **Principal Function:** to provide mechanical support for silver halide crystals

INCREASED ATOMIC NUMBER (Z)

- Increased the possibility of forming the latent image
- **Bromide:** 35 Z
- **Silver:** 47 Z
- **Iodide:** 53 Z
- **Gelatin:** 7 Z
- **Polyester:** 7 Z

3.) ADHESIVE/SUBSTRATUM LAYER

- A thin coating located between the emulsion & base
- Adheres one layer of the film
- **Purpose:** allows emulsion & base to maintain proper contact & integrity

4.) BASE

- Foundation or framework of the film
- **Purpose:** to provide a rigid structure onto which the emulsion can be coated
- **Composition:** polyester/plastic
- **Size:** 175 or 200 or 150-300 micrometer

CHARACTERISTIC OF GOOD FILM BASE

1.) SUPERIOR PHYSICAL/DIMENSIONAL STABILITY

- Maintain its size and shape without contributing to image distortion

2.) TINTED WITH BLUE DYE (1933)

- To reduce parallax effect/crossover
- To reduce eyestrain and fatigue
- Increase contrast

3.) FLEXIBLE & FRACTURE RESISTANT

- It can be snap in the viewbox/negatoscope

4.) UNIFORM LUCENCY/OPTICAL CLARITY

- In order to be seen
- Transparency should be uniform
- No unwanted pattern or shading is found on the image

5.) SEMIRIGID

6.) INERT TO PROCESSING CHEMICAL

- Does not change in form

7.) CHEMICAL MEMORY

- Remain flat

8.) NON-FLAMMABLE

9.) WATERPROOF

IMAGE PRODUCTION AND EVALUATION

PARALLAX EFFECT

- Apparent displacement of an image as seen in the radiograph

HISTORY OF FILM BASE

1.) GLASS PLATE

- The original film base
- **Characteristic:** fragile

2.) CELLULOSE NITRATE

- Standard base
- **Characteristic:** flammable

3.) CELLULOSE TRIACETATE (mid-1920s)

- Safety base
- **Characteristic:** safety base but easily torn

4.) POLYESTER (1960)

- Film base of choice
- Ethylene glycol & dimethyl terapthalate
- **Characteristics:**
    - More resistant
    - Superior dimensional stability

BASIC FILM TYPES ACCORDING TO CONSTRUCTION

1.) DUPLITIZE/DOUBLE EMULSION FILM

- Films that have emulsion layer coated on both sides of the film base
- Screen or non-screen type

2.) SINGLE-COATED

- Films that have emulsion layer on one side only

HALATION

- Reflection of screen light transmitted through the emulsion & base
- The halo unsharpness that reduces resolution
- Produced by the light photons that has already pass through the emulsion layer for single coated film

FILM CHARACTERISTICS

1.) FILM SPEED

- Degree to which the emulsion is sensitive to x-rays/light
- The exposure required to produce an optical density of 1.0 above base fog
- Increased Film Speed – Increased Sensitivity – Increased Density – Decreased mAs – Decreased Dose

FACTORS AFFECTING FILM SPEED

- Number of silver halide crystals
- The number of sensitivity center per crystals
- The concentration of crystals in the emulsion
- The size & distribution of the crystals

FACTORS AFFECTING FILM SPEED IN INTENSIFYING SCREEN

- Type/composition of phosphor
- Thickness of phosphor
- Size of phosphor
- Reflectance used

2.) FILM CONTRAST

- Refers to the ability of the radiographic film to provide a certain level of image contrast
- The difference in OD b/n 2 areas in the image
- Inherent to film manufacturer
- High contrast emulsion – good image
- Low contrast emulsion – not good image

SUBJECT CONTRAST

- Differential absorption of tissue
- Controlled by RT

3.) EXPOSURE LATITUDE

- Margin of errors
- Range of exposures that produce OD within straight line region of sensitometric curve

- Inversely proportional to film contrast
- High contrast emulsion – narrow latitude
    - Few factors can be applied
    - Near to OD required
- Low contrast emulsion – wide latitude
    - Many factors can be applied

PARTS OF THE CHARACTERISTIC CURVE

- Base plus fog
- Toe
- Shoulder
- Straight line portion

HUMAN EYE

- It has a logarithm of response to OD
- OD = Log_{10} (I_o/I_t)

DENSITOMETER

- It measures density

4.) SPECTRAL SENSITIVITY

- It refers color of light to which particular film is most sensitive

SPECTRAL EMISSION

- Color of light produced by a particular intensifying screen

5.) SPECTRAL MATCHING

- Correctly matching the sensitivity of the film to the color of emission of intensifying screen

6.) CROSSOVER

- Disadvantage of screen-film/duplitized film
- Light that has been produced by IS
- Crossover to the base and exposing the emulsion of the opposite side
- Blurred image

WAYS TO REDUCE PARALLAX EFFECT

- Tinting the film with blue dye
- Use monochromatic film
- Adding anti-crossover layer

ORTHOCHROMATIC FILM

- There is always a parallax effect
- **RATIONALE:** green is not transparent to dye

IMPORTANCE OF ADDING CROSSOVER CONTROL LAYER

- Separate layer from emulsion
- Absorb most of the crossover
- Easily dissolved in the solution

7.) RECIPROCITY LAW

- OD on a radiograph is proportional only to the total energy imparted to the radiographic film
- Applicable only in direct exposure, but not in screen-film

FILM SENSITOMETRY

- Quantitative measurement of the response of film to x-ray and exposure or development and processing
- **Frequency:**
    - Early morning when the processor reached its maximum capacity or has been warmed up

SENSITOMETER

- Optical step-wedge
- A device that produces a constant simulated, predetermined x-ray exposure
- X-ray machine is not utilized

PENETROMETER

- Aluminum step-wedge
- X-ray machine is utilized

CONTROL FILM/CONTROL BOX

IMAGE PRODUCTION AND EVALUATION

- The film used
- Exclusively used for film sensitometry

AUTOMATIC PROCESSOR
- Develop film

SENSITOMETRIC STRIP/STEP TABLET
- Made by exposing successive areas on a film with one exposure
- The image from least to maximum OD
- 11 or 24 strips
- D_{max} to D_{min}

DENSITOMETER/TRANSMISSION DENSITOMETER
- A device that measures the percentage of light transmittance
- Base Density/Manufacturer's Film Density: 0.14 OD
- **Light Transmitance:** 100% (0 OD), 10% (1 OD), 1% (2 OD) & 0.1% (3 OD)

GRAPHING PAPER/CONTROL CHART
- For plotting the H & D curve
- Hurter & Driffield

OPTICAL DENSITY
- Human eyes has a logarithm of response
- Noticeable
- **Formula:** Log_{10} (I_i/I_t) or Log_{10} (I_o/I_t)

SENSITOMETRIC CURVE
- The product of sensitivity
- Film characteristic curve or H & D curve
- **Base Plus Fog:** lowest portion (0.18 OD)
- **Toe:** $D_{min,}$ Phenidone
- **Shoulder:** $D_{max,}$ Hydroquinone
- **Straight Line Region:** Film gamma
    - Steeper = good contrast
- Film contrast, Exposure latitude, Speed/Sensitivity, Automatic processing, Phenidone & Hydroquinone

BASE DENSITY
- The density from the manufacturer of the film
- It is inherent in the film base
- **Average:** 0.14 OD

BASE PLUS FOG
- Inherent fog cause by processing conditions
- **Acceptable B+F:** 0.18 OD

MINIMUM DENSITY/D_{min}
- Low density & midpoint density
- The TOE of the characteristic curve
- Slightly higher than B+F density

MAXIMUM DENSITY/D_{max}
- Higher density & darkroom density
- The SHOULDER of the characteristic curve

AVERAGE GRADIENT
- Reflects the film contrast which is measured at 0.25 density units above B+F density and 2.0 density units above B+F
- The more vertical this line, the greater the film contrast

REJECT FILM ANALYSIS
- **Monthly:** a reject rate of 10% or more should be considered unacceptable
- A reject rate of 5-10% justifies continued monitoring

INTENSIFYING SCREEN
- It converts x-ray energy to light which exposes the radiographic film

- It intensifies or amplifies the energy to which they were exposed
- **Advantage:** decrease patient dose

LAYERS OF INTENSIFYING SCREEN

1.) PROTECTIVE COATING

- It gives physical protection to the delicate phosphor layer
- It provides a surface which can be cleaned without damaging the phosphor
- It helps prevent static
- Transparent to x-ray
- **Size:** 10-20 micrometer

2.) PHOSPHOR

- The active layer of IS
- It emits light during stimulation by x-ray
- **Size:** 50-300 micrometer or 60 mg/cm^2

3.) REFLECTIVE LAYER

- Intercepts light photons headed in other direction & redirects them to the film
- **Shiny Substances:** Magnesium oxide & Titanium dioxide
- **Size:** 25 micrometer
- **Crystal Size:** 5-15 micrometer
- 2x Film Speed – 2x Density – ½ mAs

4.) BASE

- Made of high grade cardboard or polyester
- It provides support to the phosphor layer
- **Size:** 1000 micrometer or 1 mm
- **Characteristics:**
  - Rugged & moisture resistant
  - Does not suffer radiation damage nor discoloration
  - Chemically inert & not interact with the phosphor layer
  - Flexible but not elastic
  - Does not contain impurities that would be image by x-rays

CHARACTERISTICS OF A GOOD PHOSPHOR

1.) DETECTIVE QUANTUM EFFICIENCY

- The ability of the phosphor to interact with x-ray

2.) CONVERSION EFFICIENCY

- The ability of the phosphor to convert x-ray into light
- Rare earth = high CE

3.) SPECTRAL MATCHING

- Specific color

4.) MINIMUM AFTERGLOW/LAG

- Useless but it is use in fluoroscopy

AMBIENT TEMPERATURE

- Increase temperature
- >30^o C/85^o F
- KE increases = changes color

PHOSPHOR MATERIAL

1.) CALCIUM TUNGSTATE ($CaWO_4$)

- Introduced by Thomas Alba Edison
- **Scheelit:** natural tungstate

2.) BARIUM LEAD SULFATE

- For high kVp techniques
- It was used to decrease patient dose
- Increase scatter radiation – Increase fog – Increase density – Decrease mAs

3.) ZINC SULFIDE

- For low kVp techniques
- It was used for high resolution image quality
- Decrease quantum mottle – Increase mAs

4.) RARE EARTH CRYSTALS

- **Speed:** 1000-1200
- Increase quantum mottle – Decrease mAs
- **Quantum mottle:** salt and pepper appearance
- **Disadvantage:** Increase quantum mottle

WILHELM CONRAD ROENTGEN

- Died in colon cancer
- **Wife:** Anaberta Ludwig

LUMINESCENCE
- Emission of light from the screen when stimulated by radiation

FLUORESCENCE
- The ability of phosphor to emit visible light only while expose to x-ray
- During x-ray exposure or while/promptly emitted or within 10^{-8}
- Important to Radiography

PHOSPHORESCENCE
- Continue to emit light even after x-ray exposure
- When x-ray exposure ceases or stopped
- Somewhat after 10^{-8}
- Delayed emission
- Important to Fluoroscopy

INTENSIFYING SCREEN PHOSPHOR MATERIAL AND THEIR RESPONSE

1.) CALCIUM TUNGSTATE ($CaWO_4$): BLUE

2.) RARE EARTH
- **Lanthanum oxybromide:** BLUE
- **Yttrium tantalite:** UV/BLUE/GREEN
- **Gadolinium oxysulfide:** GREEN

SCREEN SPEED
- The capacity of the screen to produce visible light
- Increase screen speed – Increase light emission – Increase density – Decrease density

FACTORS DETERMINING SPEED OF THE SCREEN
- Type of phosphor
- Phosphor thickness
- Phosphor size
- Reflectance of the screen backing

SCREEN FACTOR

1.) THICKER PHOSPHOR LAYER
- Increase screen speed – Increase quantum mottle – Decrease recorded detail
- Increase screen speed – Increase light emission – Increase density – Decrease mAs – Decrease patient dose

2.) LARGE PHOSPHOR CRYSTAL SIZE
- Same as above

3.) REFLECTIVE LAYER
- 2x screen speed – Increase quantum mottle – Decrease recorded detail
- 2x screen speed – 2x light emission – 2x density – Decrease mAs – Decrease patient dose

3.) ABSORBING LAYER
- Decrease screen speed – Decrease quantum mottle – Increase recorded detail
- Decrease screen speed – Decrease light emission – Decrease density – Increase mAs – Increase patient dose

4.) DYE IN PHOSPHOR LAYER
- Same as above

INTENSIFICATION FACTOR
- Intensifying action of the screen
- A measure of screen speed
- **Formula:**
  - Exposure w/o screens ÷ Exposure w/ screens
- Increase IF – Increase intensifying action

SPEED VALUE

IMAGE PRODUCTION AND EVALUATION

- The most common method of designating screen speed
- **Formula:** New mAs = (Old mAs x Old Relative Speed Value) ÷ New Relative Speed Value
- Fast speed – Increase light emission – Decrease sitting requirement
- Slow speed – Decrease light emission – Increase sitting requirement
- Decrease screen speed – Decrease light emission – Decrease density – Increase mAs – Increase patient dose
- Increase screen speed – Increase light emission – Increase density – Decrease mAs – Decrease patient dose
- Increase crystal size – Thicker phosphor – Increase screen speed

INTENSIFYING SCREEN SPEED

25 – Ultra Detail
50 – Slow/High Resolution/Detailed
100 – Standard/Medium/Par
200 – Fast/High Speed
300 – Ultrafast/Hi-plus
1200 – Rare Earth

RELATIVE SPEED

- The ability of the screen to produce light and density
- **Formula:** mAs_1/mAs_2 = relative $speed_2$/relative $speed_1$

WATER TEMPERATURE

- >2.8-3.0^o C/5^o F than developer temperature
- If water temperature is greater than developer temperature, developer activity increases

90 SECONDS AUTOMATIC PROCESSOR

- 33.8-35^o C/90-95^o F

QUANTUM MOTTLE/IMAGE NOISE

- Statistical fluctuation in the quantity of x-ray photons that contributes to image per mm^2
- Low x-ray photons – Increase mottled/splotchy appearance

SCREEN MAINTENANCE

- **Frequency:** regular cleaning
- Anti-static compound/solution or 70% isoprophyl alcohol or mild/body soap
- Do not use detergent
- **Cotton balls:** for even cleaning
- **UV light:** to identify stain
- **Compression layer/Contact felt:** maintain proper screen-film contact
- **Poor screen-film contact:** blurry image
- **Common cause:** foreign matter under the skin
- **Wire Mesh Test:** used to evaluate proper screen-film contact

CAUSES OF POOR SCREEN-FILM CONTACT

- Worn contact felt
- Loose, bent or broken latches (lock)
- Loose, bent or broken hinges
- Warped screen cause by excessive moisture
- Warped cassette front
- Spring or cracked cassette frame
- Foreign matter under the screen (most common cause)

FILM CASSETTE

CASSETTE FRONT

- Low atomic number
- No x-ray interaction (radiolucent)
- **Composition:** Bakelite/Carbon fiber

LEAD FOIL

- Absorbs backscatter radiation

CASSETTE BACK

- Steal of light weight of metal
- **Composition:** Magnesium/Magnesium

PHOTOTIMER CASSETTE

- Radiolucent back to permit the radiation reaching the film to continue in the AEC
- No lead foil

GURNEY-MOTT THEORY

- Before exposure, silver halide (AgBr & AgI) is suspended in gelatin in the emulsion layer
- Sensitivity specks (latent image center) exist as a physical imperfection
- Exposure to x-ray and light ionizes the silver halide
- Negative charged electrons and positive charge silver ion float freely in the emulsion gelatin
- Sensitivity specks trap electrons
- Each trapped electron attracts a silver ion
- Silver clamps around the sensitivity specks
    - 4-10 silver atom pairs

GURNEY-MOTT THEORY

- The only accepted theory in the explanation of photographic effect
- Indicates that x-rays and visible light cause ionization of the atoms in the crystal
- Ionized crystal are said to be exposed

MITCHELL THEORY

- Modern theory

SENSITIVITY CENTER

- Physical imperfection in the lattice of the emulsion layer that occurs during the film manufacturing process
- Latent image center or the focal point

SILVER SULFIDE

- A chemical contaminant responsible for the physical imperfection of the silver halide crystal

TYPES OF IMPERFECTION

1.) POINT DEFECT

- Occur when silver ions moves out from the cubical lattice formation

2.) SENSITIVITY SPECK/CENTER

- Occurs when silver ions are trapped because of chemical impurities in the gelatin

3.) LATENT IMAGE CENTER

- Refers to clumping or grouping of silver ions

4.) FRANKEL DEFECT

- Physical imperfection
- Consists of interstitial silver ions and silver ion vacancies

IMAGE PROCESSING

1.) LATENT/POTENTIAL IMAGE

- Refers to the image that exists on film after it has been exposed but before it has been processed

2.) VISIBLE/MANIFEST IMAGE

- Black metallic silver
- Exists on film after exposure and processing

DEVELOPMENT OF VISUAL IMAGE

- "Without interaction, there is no development"
- The developer provides electrons for the reduction of the SHC
    - By giving up electrons, the developer is oxidized
    - By gaining electrons, the SH is reduced
- REDOX = EUR/OPE (**E**lectrons are **U**sed in **R**eduction; **O**xidation **P**roduces **E**lectrons)

IMAGE PRODUCTION AND EVALUATION

PROCESSING OF RADIOGRAPH

1.) DEVELOPER

- Convert latent image to visible image
- To amplify the amount of metallic silver on the film by increasing the number of silver
- To reduce the exposed SHC into metallic silver

A. REDUCING AGENTS

- Elon/Metol/Phenidone/Hydroquinone
- Reduced exposed AgBr crystals to black metallic Ag
- Metol (Manual) & Phenidone (Automatic)
  - Build up detail quickly in 1st half of the development process
  - Speed indicator
  - Rapid reducing
  - 1.2 OD
- Hydroquinone
  - Builds up contrast slowly during development period
  - Principal component
  - Contrast indicator
  - Sensitive to light and temperature
  - **PQ:** for automatic processing
  - **MQ:** for manual processing

B. ACTIVATOR/ALKALINIZER/BUFFERING AGENT/ACCELERATOR/WETTING AGENT

- Sodium hydroxide/bicarbonate & Potassium hydroxide/bicarbonate
- Maintain alkalinity
- Provides necessary alkaline medium
- Swells gelatin emulsion so that reducing agents can attack AgBr crystals
- pH = 9-6-10-6 or 10-11.5 or 10-12

C. RESTRAINER

- Sodium bromide/iodide or Potassium bromide/iodide
- Decreases activity of developing agent
- **REGULATOR:** controls activity of reducing agents
- **ANTI-FOGGANT:** tends to prevent fog
- **STARTER SOLUTION:** first to take effect to reduce developer activity

D. PRESERVATIVE/CYCON

- Same with fixer
- Prevent rapid oxidation of the reducing agent
- Reacts with QUINONE (by produce of Hydroquinone which is a dye), capable of staining the film and form colorless compound called **HYDROQUINONE MONOSULFATE**
- **STABILIZER:** to promote equilibrium of chemicals
- **ANTI-OXIDANT:** prevents internal oxidation
- pH = 3-4 (Preservative, Restrainer & Hardener)

E. SOLVENT

- Drinking water
- Not tap water
  - It creates artifacts

OTHER COMPONENTS

1.) HARDENER/TANNING AGENTS

- Dialdehyde/Glutaraldehyde
- For automatic processing only
- Added for developer solution to prevent swelling of emulsion
- Reduces film transportation problems & preventing damage to the emulsion
- **Developer:** weak/temporary hardener

- **Fixer:** strong/permanent hardener

2.) BENZOTHIOSOLE

- An organic restrainer which added to PQ developer
  - Prevent action of phenidone on the unexposed crystals, since phenidone is not restrained by bromide
- **1956:** first roller transport system uses hardener

3.) SEQUESTERING AGENTS

- Prevent precipitation of calcium sludge
- Oily substance & precipitate of aluminum
- **EDTA:** sodium salt of Ethylene Diamine Tetra Acetic Acid
- **CALGON:** sodium hexametaphosphate
- **CHELATES:** boric acid/salts

4.) WETTING AGENTS

- Sodium hydroxide/carbonate
- Stimulate uniform development

5.) ANTIFROTHANT/ANTI-FOAMING

- Prevent bubble formation in the solution
- Prevents aerial and external oxidation
  - Closefitting lids
  - Mixing paddle
  - Hose should not be used

6.) FUNGICIDES

- **Fungi:** develop in complete darkness and moisture
- Virus, bacteria & protozoa

7.) BUFFER

- **Developer:** Sodium hydroxide/carbonate
- **Fixer:** Acetic acid/Sulfuric acid
- Maintains pH value of the solution

OXIDIZED DEVELOPER

- Old or exhausted developer
- Decrease reducing property (aerial/chemical oxidation)
- Product of developing as increased monosulfate
- All agent's activity are decreased, except for Restraining Agent

REPLENISHMENT

- Physical and chemical means of maintaining the level of processing solution

REPLENISHER

- A solution containing more reducing agents, activator and preservative but without restrainer to maintain chemical activity of the processing solution to the original & in proper dilution with water
- **MQ Replenisher:** without restrainer
- **PQ Replenisher:** with restrainer (BENZOTHIOSOLE)

FLOOD VOLUME REPLENISHMENT SYSTEM

- 25-50 pcs of 14x14 or 14x17 films developed/day

MICROSWITCH

- A device located at the entrance of the automatic processor which controls the replenishment rate of processing chemicals
- Replenishment rate are normally established on the basis how much chemistry is required per 14 in of film travel
- **Developer:** 60-70 cc or 4-5 mL/in
- **Fixer:** 100-110 cc or 6-8 mL/in
- **14x14 or 14x17 in:** replenishment occurs
- **8x10 in:** no replenishment occurs
- **Oxidized developer:** many big films are developed

- **Overreplenishment:** many big films are developed; increases density

FLOOD/TIMED/STANDBY/TITUS REPLENISHMENT SYSTEM

- Donald Titus of Kodak
- Replenish every 10 mins or 1 hour
- <25-50 14 in films
- No microswitch but with timer
- Many films are replenished

SUPERADDITIVITY/SYNEGISM

- Activity of each individual component of reducing agent in solution is less that the activity when two components are combined

CLASSIFICATION OF DEVELOPER

1.) MQ DEVELOPER

- Elon/metol-hydroquinone developer

2.) PQ DEVELOPER

- Phenidone-hydroquinone developer
- 15 times more superadditivity than MQ developer combination

FACTORS AFFECTING DEVELOPMENT TIME

- **Temperature of the solution:**
  - Increase temperature – Increase activity – Decrease time of development
- **Size of film:**
  - Big film size – Longer DT
- **Size of grains of the film:**
  - Larger/thicker SHC – Increase development time (Same as direct exposure)
- **Agitation:** circulation system
  - Increase agitation – Increase interaction – Shorter DT
- **Exhaustion of the developer:**
  - Decrease developer activity – Longer DT

2.) FIXING

- STOP BATH/SHORT STOP/ACID RINSE BATH
- 1% of acetic acid
- **PRIMARY:**
  - Removes, dissolves & clears away silver halide from film
  - To permanent the image
- **SECONDARY:**
  - To stop development process
  - To further hardens the emulsion
- It serves to clear the film of the undeveloped crystals, forming a Ag complex of thiosulfate technically called **MONOARGENTO-DI-THIOSULFURIC ACID**

A. CLEARING AGENT/FIXING AGENT

- Sodium thiosulfate (Manual Processing)
- Ammonium thiosulfate/hypo (Automatic Processing)
- Dissolves unexposed AgBr crystals, thereby producing a permanent visible image
- **Oxidized developer:** strong ammonia odor
- **Hyporetention/Thiosulfate retention:**
  - Silver sulfide stain
  - Pale yellow or brown color (brown stain)

WASHING

- Very important to archival quality
- Prevent hyporetention

THIO

- Function is to dissolve silver
- **Thio silver sulfate:** Ag enter to thio
- Hyporetention

HYPOKIT

- A chemical that is dropped to the film
- Presence of thiosulfate = changes color
- Many thiosulfate = brown color
- Chemical used = acetic acid, silver nitrate & solvent

AMMONIUM THIOSULFATE VS SODIUM THIOSULFATE

- **Ammonium:** for automatic processing; better than sodium
  - Fixes the film more rapidly than Na thiosulfate when present equivalent concentration
- **Sodium:** for manual processing

B. NEUTRALIZER/ACTIVATOR/ACIDIFIER /BUFFERING AGENT

- Acetic acid/Sulfuric acid
- Provides an acid medium and neutralized the developer carried over on the film
- To activate Thio to enter and get Ag
  - It will not function when the medium is not acid
- pH = 4.2-4.9
- Increase carryover of alkaline from developer
- **Alkaline:** low H^+ high OH^-; potential hydrogen
- **Acid:** high H^+ low OH^-

C. PRESERVATIVE / STABILIZER / CYCON / ANTI-OXIDANT

- Sodium sulfite/Potassium sulfite
- Maintains equilibrium of the chemical in the solution
- Prevents internal oxidation
- Prevent aerial oxidation of fixing agent
- Prevent decomposition and precipitation of sulphur from the thiosulfate fixing agent
- Responsible in removing silver to thio
- **Oxidized developer:** increase monosulfate
- **Oxidized fixer:** increase sulfurization

D. HARDENER / STRONG HARDENER / TANNING AGENT / PERMANENT AGENT

- Potassium aluminium/Chromium aluminium/Alum chloride
- Major component
- Raises temperature at which gelatin softens
- Prevents too much absorption of water by gelatin
- Makes the film less susceptible to physical change
- Increase temperature, aluminium enters

E. SOLVENT

- Water

SEQUESTERING/BUFFERING AGENT

- **Boric acid/salts**
  - An anti-sludging agent which delay precipitation of Al hydroxide (alkaline)
    - Increases pH
- **Hyponeutralizer**
  - Solution used between fixing stage and the final washing cycle to decrease the washing time of the film to prevent hyporetention
- **Clearing**

- The process by which the fixing agent acts on the unexposed to form soluble complexes which eventually diffuses out of the film into fixing solution
- Fixing Time = 2x Clearing Time (OLD)
- Fixing Time = Clearing Time + Hardening Time (NEW)

3.) WASHING

- Removes residual processing (thio) and Ag salts from the radiograph
- Water
- < 2.8^{o} C/5^{o} F of developer temperature
- **MAIN FUNCTION:** to stabilize developer temperature
- Change = 0.3^{o} C
- Important to archival quality to prevent hyporetention

4.) DRYING

- Final process
- Removes 85-90% of moisture from the film so that it can be handle easily and stored while maintaining quality of the diagnostic image
- 10-15% remaining
- Consuming more electricity (60-80% electrical consumption)
- **Rationale:**
  - Filament = 1500-2500 W
  - Air blower = 100-300 cu-ft/min

TEMPERATURE CONTROL

- Tempering system
- Increase and decrease in developing temperature can adversely affect the quality of radiographic image
- 90 secs = 33.8-35^{o} C/93-95^{o} F

GROSS CONTROL TEMPERATURE/WARM WATER PROCESSOR

- Used HOT WATER
- Affected by WATER-MIXING VALVE, a device that interconnect the incoming hot and cold water

FINE CONTROL/THERMOSTATICALLY-CONTROLLED TEMPERATURE PROCESSOR

- Uses COLD WATER
- Occurs within the developer tank itself through a thermostatically-controlled heating element by means of heat exchanger
- **Thermostat:** controls temperature
- Heating element or heat exchanger or metal tube
- More advisable than gross control temperature

PROCESSING SYSTEM TANKS

- Automatic processor has 3 tanks

1.) Developer Tank
2.) Fixer Tank
3.) Water Tank

CASCADE COMPARTMENT

- 2 wash tank

AUTOMATIC PROCESSOR

- A device that has roller transport system
- A device that comprises chemical tanks
- A dryer system for processing of radiographic film

PROCESSING CYCLE/DRY-TO-DROP TIME

- Time to process a single piece of film
- 45 seconds to 3.5 minutes

IMAGE PRODUCTION AND EVALUATION

PROCESSING CAPACITY

- Number of film that can be processed per hour

TRANSPORT SYSTEM

1.) VERTICAL TRANSPORT SYSTEM

- Used in automatic processor
- Advance the film through different stages
- All rollers & feed tray

A. ENTRANCE ROLLER

- Grab the film
- Covered with corrugated rubber (rubberized)
- Plexi glass, Polyester & Phenolic

B. TRANSPORT/PLANETARY ROLLER

- Vehicle transport
- Moves the film through the chemical tanks and dryer
- **Size:** 1 inch

C. TURNAROUND/SOLAR/MASTER ROLLER

- Bottom of the roller assembly
- Turns the film from moving down the transport assembly to moving up the assembly

D. CROSSOVER ROLLER

- Moves the film from one tank to another
- From fixer to developer

E. SQUEEGEE ROLLER

- Specialized rubber area

GUIDE PLATES

- Slightly curved metal plates
- Properly guide the leading edge of the moving film through

MOTOR DRIVE

- An electric motor
- Provides power for the roller assembly to transport the film through the processor
- On/off switch provides electric power
- **Disadvantage:** stand by control
    - An electric circuit that shuts off power to the roller assembly
- Belt and pulley

RADIOGRAPHIC APPEARANCE

DECREASE IN DENSITY

- Developer exhausted
- Developer underreplenishment
- Processor running too fast
- Low developer temperature
- Developer improperly mix

INCREASE IN DENSITY

- Developer overreplenishment
- Increase developer temperature
- Light leak in processor
- Developer improperly mixed

PINKISH/DICHROIC STAIN

- Contamination of developer by fixer (chemical fog)
- Developer or fixer underreplenishment

BROWN STAIN/THIOSULFATE

- Inadequate washing

EMULSION REMOVED BY DEVELOPER

- Insufficient hardener in developer

MILKY APPEARANCE

- Fixer exhausted
- Inadequate washing

STREAKS

- Dirty processor rollers
- Inadequate washing and drying

ALTERNATIVE PROCESSING METHODS

IMAGE PRODUCTION AND EVALUATION

1.) RAPID PROCESSING

- 30 seconds
- Useful for angiography, special procedure, surgery & emergency room
- More concentrated chemicals
- Higher developer and fixer temperature

2.) EXTENDED PROCESSING

- 3 minutes
- Mammography
- For single emulsion only
- **Advantages:** greater image contrast & lower patient dose
- **Disadvantage:** longer dry-to-drop time

3.) DAYLIGHT PROCESSING

- 2 minutes
- Receive film in 15 seconds
- Uses microprocessor
- Advantages: no darkroom required & speed

RADIOGRAPHIC ARTIFACTS

- Unwanted image

POSITIVE DENSITY ARTIFACT

- Radiolucent appearance
- **Halfmoon marks:** bending & kinking of film
- **Scratching/Abrasion:** fingernail/scratch
- **Static discharge:** sliding films over flat surface
- **Fogging:** exposure to white light, ionizing radiation, heat, safelight fog & expired film
- **Density outside collimation area:** off-focused/off-skin radiation

NEGATIVE DENSITY ARTIFACT

- Radiopaque appearance
- **Finger print:** moisture on finger transferred to the film before exposure
- **Scratches/Abrasions:** scrapping or removing emulsion
- **Foreign objects:** some unintended object in the imaging chain
- **Non-specific decrease:** dirty screens or cassette

SILVER RECOVERY

1.) PRECIPITATION OF THE SILVER

- Oldest form of silver recovery
- Chemical precipitation
- Involves chemical reaction
- Ag in fixer solution is precipitated as Ag sulphide by adding Na sulphide to the solution

2.) METALLIC REPLACEMENT / DISPLACEMENT

- Used of aluminum steel wool
- Cartridge
- Least expensive and simplest

3.) ELECTROLYTIC RECOVERY UNITS

- Most common
- An electric current is passed through an ionized solution
- **Two electrodes:** Anode (Carbon) & Cathode (Stain-steel)
- Ag is retrieved in the cathode

TROY OZ

- Unit of silver recovery

USE OF SILVER RECOVERY

1.) Photographic Industry: 30%
2.) Electric Industry: 20%
3.) Sterling Industry: 15%

RADIOGRAPHY

- Used of ionizing radiation

RADIOGRAPH

IMAGE PRODUCTION AND EVALUATION

- Image produced with good quality

TECHNICAL COMPETENCY

- Operation of the control panel
- Selection of appropriate accessories
- Use of terminologies in evaluation of radiograph
- Measurement
- Evaluation of result

CHARACTERISTIC OF RADIOGRAPH

- Exposure factor is adequate
- Adequate penetration
- Sufficient density and contrast
- Field size selection is appropriate
- No motion
  - **Voluntary:** good communication
  - **Involuntary:** decrease exposure time

KILOVOLTAGE PEAK (kVp)

- Controls energy of the beam
- Penetrating ability
- Accelerates the electron
- Wavelength of photon
- Affects blackening of film by 15% rule
- Affects the production of scattered radiation
- Controls radiographic contrast
- Affects exposure to patient

MILLIAMPERAGE (mA)

- Number of electrons
- Number of x-ray photons
- Blackening
- Influences focal spot blooming
  - Increase actual focal spot size when the tube current is increased

TIME (s)

- Length of exposures
- Number of photons exposing the patient with mA-timer relationship

DISTANCE

- **FFD/SID:** distance from the focal spot to the recording medium
- Affects blackening of film
- Inverse square law

RADIOGRAPHIC QUALITY

A. PHOTOGRAPHIC ASPECT/VISIBILITY

- **Density:** overall blackening of the film
- **Contrast:** variation in the density level that makes detail visible

B. GEOMETRIC ASPECT/SHARPNESS

- **Definition:** clarity and sharpness of structural lines
- **Distortion:** undesired change in the size and shape of the anatomic part

RADIOGRAPHIC DENSITY

- Determines the amount of density on finished radiograph
- **Acceptable Range:** 0.25-2.0 OD
- Directly related to mAs

FACTORS AFFECTING DENSITY

- **Controlling factor:** mAs
- kVp, Distance, Grids, Film Screen Speed, Collimation, Anatomic Part, Anode Heel Effect, Reciprocity Law, Generator Output, Filtration & Film Processing

FACTORS TO REMEMBER IN DENSITY

- **Increase mAs:** great density

IMAGE PRODUCTION AND EVALUATION

- **Fastest screen film combination:** great density
- **Lowest grid ratio:** great density
- **Direct exposure technique:** least density
- **Shortest distance:** great density
- **Longest time:** great density
- **Highest kVp:** great density
- **Smallest area of collimation:** least density

INFLUENCING FACTORS

- 15% kVp rule
- **Increase Density:** original kVp + 15%
- **Decrease Density:** original kVp –15%
- **Maintain Density:** original kVp + 15%, mAs ÷ 2
- **Decrease Patient Dose:** original kVp + 15% and mAs ÷ 2
- **Increase Image Quality:** original kVp – 15% and mAs x 2

ANODE HEEL EFFECT

- Used long FFD and shortest/smallest field size
- **Anode Side:** 75%
- **Cathode Side:** 120%
- **Difference:** 45%

INVERSE SQUARE LAW

- Intensity of x-ray is inversely proportional to the square of distance

RECIPROCITY LAW

- States that OD on a radiograph is proportional only to the total energy imparted to the radiographic film
- Accurate only on direct exposure
- Fails in screen-film

RADIOGRAPHIC CONTRAST

- To make detail visible
- Attenuation and differential absorption

TYPES OF CONTRAST

1.) SUBJECT CONTRAST

- Differential absorption of adjacent structures
- Affects by kVp, tissue composition & CM

2.) FILM CONTRAST

- Inherent in the film base
- Affects by film (IR), film type & direct/IS exposure

CHARACTERISTIC OF CONTRAST SCALE

1.) SHORT SCALE

- Few number of useful densities on the radiograph
- Abrupt change from one density to another
- High contrast, more contrast & narrow latitude
- Low kVp technique

2.) LONG SCALE

- Large number of useful densities on the radiograph
- Little change from one density to another
- Low contrast, less contrast & wider latitude
- High kVp technique

HIGH kVp	LOW kVp
Long scale contrast	Short scale contrast
Low contrast	High contrast
Less contrast	More contrast
Wide latitude	Narrow latitude

CONTRAST

- **Influencing factor:** kVp
- Grids, Collimation, OID, CM, Processing & Air-gap Technique

IMAGE PRODUCTION AND EVALUATION

CASTS

- **Fiber glass:** no increase in exposure factor
- **Wet Plaster:** increase mAs 3x
- **Dry Plaster:** increase mAs 2x

SPLINTS

- **Fiber glass:** no increase in factor
- **Inflatable (Air):** no increase in factor
- **Wood, Aluminum & Plastic:** increase exposure if they are in the path of primary beam

PATHOLOGY

1.) ADDITIVE DISEASES

- Increases absorption characteristic
- Increase kVp
- Aortic aneurysm, Ascites, Atelectasis, Cirrhosis, Hypertrophy, Metastases, Pleural effusion, Pneumonia & Sclerosis

2.) DESTRUCTIVE DISEASES

- Decreases absorption characteristic
- Decrease kVp
- Active TB, Atrophy, Bowel obstruction, Cancer, Degenerative arthritis, Emphysema, Osteoporosis & Pneumothorax

RADIOGRAPHIC DEFINITION/RECORDED DETAIL

- Clarity and sharpness
- **Umbra:** true image
- **Penumbra:** geometric unsharpness; the blurred areas around the umbra

DISTORTION

- Used to removed superimposition
- **Magnification:**
    - Distortion in size
    - Increase FFD – Decrease OFD – Decrease magnification
- **Foreshortening/Elongation:**
    - Irregular magnification
    - Distortion in shape
    - Affected by CR part-film alignment

RELATIONSHIPS

- Increase mAs – Increase Density
- Decrease mAs – Decrease Density
- Increase kVp – Increase Density – Decrease Contrast
- Decrease kVp – Decrease Density – Increase Contrast
- Increase SID – Decrease Density – Increase Detail – Decrease Distortion
- Decrease SID – Increase Density – Decrease Detail – Increase Distortion
- Increase OID – Decrease Density – Increase Contrast – Decrease Detail – Increase Distortion
- Decrease OID – Increase Density – Decrease Contrast – Increase Detail – Decrease Distortion
- Increase Grid Ratio – Decrease Density – Increase Contrast
- Decrease Grid Ratio – Increase Density – Decrease Contrast
- Increase Film-Screen Speed – Increase Density –Decrease Detail
- Decrease Film-Screen Speed – Decrease Density – Increase Detail
- Increase Collimation – Decrease Density – Increase Contrast
- Decrease Collimation – Increase Density – Decrease Contrast
- Increase Focal Spot Size – Decrease Detail
- Decrease Focal Spot Size – Increase Detail
- Increase CR Angle – Decrease Density – Decrease Detail – Increase Distortion

IMAGE PRODUCTION AND EVALUATION

CONTROL OF SCATTER RADIATION

PRODUCTION OF SCATTER RADIATION

TWO TYPES OF X-RAYS RESPONSIBLE FOR THE OPTICAL DENSITY & CONTRAST ON A RADIOGRAPH

1.) X-rays that pass through the patient without interacting
2.) X-rays that are scattered within the patient through Compton interaction

REMNANT X-RAYS

- X-rays that exit from the patient

IMAGE-FORMING X-RAYS

- X-rays that exit & interact with the image receptor

PROPER COLLIMATION

- **Effects:**
    - Less scatter radiation
    - Reduces patient dose
    - Improves contrast resolution

THREE FACTORS CONTRIBUTE TO INCREASED SCATTER RADIATION

1.) kVp
2.) Field Size
3.) Patient Thickness

kVp

- **Increase kVp:** increases scattered radiation
    - **Rationale:** the relative number that undergo Compton interaction increases
    - **Result:** reduced image contrast
- **Decreased kVp:** decreases scattered radiation
    - **Results:**
        - Minimum scatter radiation
        - Improved image contrast
        - Increased patient dose
            - Due to increased mAs

TAKE NOTE:

- Approximately 1% of x-rays incident on the patient reach the image receptor

FIELD SIZE

- **Increase Field Size:** increases scatter radiation
- **Reduce Scatter Radiation:** lowers radiographic optical density
    - **Effect:** increased radiographic technique to increase OD

PATIENT THICKNESS

- **Increased Thickness:** increases scattered radiation
    - **Rationale:** more x-rays undergo multiple scattering
- **Compression Paddle:**
    - Used to reduce scatter radiation to the image receptor
- **Compression of anatomy**:
    - Improves spatial resolution & contrast resolution
    - Lowers patient dose
    - Important to mammography

CONTROL OF SCATTER RADIATION

CONTRAST

- One of the most important characteristics of image quality
- The visible difference between light & dark areas on an image
- The degree of difference in OD between areas of a radiographic image

CONTRAST RESOLUTION

- The ability to image & distinguish soft tissues

EFFECT OF SCATTER RADIATION ON IMAGE CONTRAST

- **High Contrast:** use of only transmitted & unattenuated x-rays
    - **Appearance:** sharp image
- **No Contrast:** use of only scattered x-rays

  - **Appearance:** dull gray image
- **Moderate Contrast:** use of both transmitted & scattered x-rays

DEVICES THAT REDUCED SCATTERED RADIATION

1.) Beam Restrictors
2.) Grids

BEAM RESTRICTION

- **Purpose:**
  - Limiting patient exposure
  - Reducing scattered radiation

BEAM RESTRICTORS

1.) APERTURE DIAPHRAGM

- Simplest type
- A flat piece of lead that has hole in it

2.) CONE/CYLINDER

- Modification of aperture diaphragm
- Has an extended flange attached to it

3.) COLLIMATOR

- Best type
- Useful and accepted type of beam-restricting device

4.) AUTOMATIC COLLIMATOR

- Positive beam limiting devices (PBL)
- Automatically limits the size and shape of primary beam to the size and shape of the IR

RESTRICTING THE PRIMARY BEAM	
Increased	**Result**
COLLIMATION	Decreased patient dose Decreased scattered radiation Increased radiographic contrast Decreased radiation density
FIELD SIZE	Increased patient dose Increased scattered radiation Decreased radiographic contrast Increased radiation density

RADIOGRAPHIC GRID

- Device used to reduce the intensity of scatter radiation in the remnant x-ray beam
- **Principal Function:** to improve image contrast
- **Secondary function:** to absorb scattered radiation
- **Used when:**
  - Anatomical part >10 cm
  - >60 kVp is used
- **Advantage:** improved image contrast
- **Disadvantages:**
  - Higher technical factors used
  - High patient dose
- **Position:** between the patient & IR

GRID CONSTRUCTION

1.) GRID STRIPS/LINES

- Radiopaque material
- **Purpose:** it absorbs scattered radiation
- **Composition:** lead (Pb)
  - **Advantages:**
    - Easy to shape
    - Inexpensive
    - High atomic number
    - High mass density
- **Characteristics:** thin & high absorption properties
- **Size:** 50 µm wide

2.) INTERSPACE MATERIAL

- Radiolucent material
- **Purpose:** to maintain a precise separation between the delicate lead strip of the grid
- **Compositions:**
  - **Aluminum (Al)**
    - **Advantages Over Fiber:**
      - High atomic number
      - Produces less visible grid lines
      - **Nonhygroscopic:** does not absorb moisture
      - Easier to manufacture

IMAGE PRODUCTION AND EVALUATION

- **Disadvantages Over Fiber:**
  - Increases absorption of primary beam
  - **Results:** higher mAs & higher patient dose
- **Plastic fiber**
  - More preferred than Al
- **Size:** 350 μm wide

THREE IMPORTANT GRID DIMENSIONS

1.) Grid Strip Thickness (T)
2.) Interspace Material Width (D)
3.) Grid Height (h)

GUSTAVE BUCKY (1913)

- He invented stationary grid
- He demonstrated the technique for reducing the amount of scatter radiation that reaches the IR

GRID SURFACE X-RAY ABSORPTION

$$\text{\% X-ray Absorption} = \frac{\text{width of grid strip}}{\text{width of grid strip + width of interspace}} \times 100$$

GRID CONTRUCTION CAN BE DESCRIBED BY:

1.) GRID RATIO

- The height of the grid divided by the interspace width
- **Formula:** grid ratio = h/D
  - h = the height of the lead strips
  - D = the distance between lead strips
- **High Ratio Grid:**
  - **Advantage Over Low Ratio Grid:**
    - More effective in cleaning up scatter radiation
    - **Rationale:** angle of deviation is smaller
  - **Disadvantage:** increases patient dose
- **General Radiography:** 8:1 to 10:1
- **Mammography:** 4:1 to 5:1

2.) GRID FREQUENCY

- The number of grid strips per centimeter or inches
- **High Frequency:** less distinct grid lines on a radiograph
- **Range:** 25-45 lines/cm or 60/110 lines/inch

$$\textbf{Grid Frequency} = \frac{10{,}000\ \mu\text{m/cm}}{(T+D)\ \mu\text{m/linepair}}$$

- T = grid strips thickness/width
- D = interspace width
- **High Frequency Grids:**
  - Requires radiographic technique
  - **Result:** higher patient radiation dose

GRID PERFORMANCE

1.) CONTRAST IMPROVEMENT FACTOR

- Ratio of radiographic contrast with a grid to that without a grid
- Best measure of how well a grid performs
- **Purpose:** measures improvement in image quality when grids are used
- **Symbol:** k

$$k = \frac{\text{image contrast with grid}}{\text{image contrast without grid}}$$

- **Most Grids:** k=1.5-2.5
- **k=1:** no improvement
- **Use of Grid:** double the image contrast
- **High Grid Ratio:** high *k*

2.) BUCKY/GRID FACTOR

- Ratio of incident radiation to transmitted radiation through a grid
- Ratio of patient dose with & without a grid
- **Purpose:**
  - To measure how much of an increase in technique will be required compared with nongrid exposure
  - Indicates how large an increase in patient dose will accompany the use of a particular grid
- **Symbol:** B

$$\mathbf{B} = \frac{\text{incident remnant x-rays}}{\text{transmitted image-forming x-rays}}$$

$$\mathbf{B} \quad \frac{\text{patient dose with grid}}{\text{patient dose without grid}}$$

=

- **Higher Grid Ratio:** higher Bucky factor
  - **Rationale:** penetration of scatter radiation becomes less likely
- **Increasing kVp:** increases Bucky factor
  - **Rationale:** more scatter radiation is produced & it has more difficult time of penetration
- **Increased Bucky Factor:**
  - **Effects:**
    - Increase radiographic technique
    - Increase patient dose

GRID PATTERN

- Refers to the linear pattern of the lead lines of a grid

TWO TYPES OF GRID PATTERN

1.) LINEAR/PARALLEL GRID

- Simplest type
- It has lead lines that run into one direction
- It cleans up scatter radiation in one direction
- **Grid Strips:** parallel
- Most popular in terms of grid pattern
  - **Rationale:** allows angulation of the x-ray tube
- **Advantage:** easiest to manufacture
- **Disadvantage:** grid cutoff
  - *Occur at:* short SID & large area IR
- **Optical Density:** decreases toward the edge of IR

2.) CROSSED/CROSS-HATCHED GRID

- It is fabricated by sandwiching two parallel grids together
- It has lead lines that run at right angle to one another
- **Grid Strips:** perpendicular
- **Advantages:**
  - Not too difficult to manufacture
  - Not excessively expensive
- **Disadvantages:**
  - Grid cutoff
  - Critical grid positioning
  - Tilt table techniques
    - Possible only if x-ray tube & the table are properly aligned
  - Exposure technique required is substantial
    - **Result:** higher patient dose
- **Advantages Over Parallel Grid:**
  - More efficient in cleaning up scatter radiation
  - Higher contrast improvement factor than parallel grid with twice grid ratio
  - Advantage increases with increasing kVp

TAKENOTE!!!

- The main disadvantage of parallel & crossed grids is grid cutoff

GRID FOCUS

- Refers to the orientation of the lead lines to one another

TWO TYPES OF GRID FOCUS

1.) FOCUSED GRID

- **Grid Strips:** parallel to primary x-ray path
- **Purpose:** to minimize grid cutoff
- **Advantage:** reduce grid cutoff
- **Disadvantages:**
  - Difficult to manufacture
  - Geometric limitations
    - Intended focal distance
    - Side of the grid should face the x-ray tube
- **Characteristics:** same with parallel grid but exhibit no grid cut off

2.) PARALLEL/NON-FOCUSED GRID

- **Grid Strips:** parallel to one another
- **Applications:** fluoroscopy & mobile imaging

TYPES OF GRIDS

1.) WAFER GRID

- Matches the size of cassette
- Use by placing on top of the image receptor

2.) GRID CASSETTE

- An image receptor that has a grid permanently mounted to its front surface

3.) GRID CAP

- It contains a permanently mounted grid
- It allows the image receptor to slide behind it

GRID CUTOFF

- The undesirable absorption of primary x-ray by the grid
- **Cause:** improper grid position
- **Primary Radiographic Effects:**
  - Further reduction in the number of photons reaching the IR
  - Decrease in radiographic density
- Most common to parallel grid
- **Distance To Grid Cutoff:** SID ÷ Grid ratio

TYPES OF GRID CUTOFF ERRORS (GRID PROBLEMS)

CENTRAL RAY

- The x-ray that travels along the center of the useful x-ray beam

1.) OFF-LEVEL GRID

- Occurs when the x-ray beam is angled across the lead strips
- Only problem in parallel & crossed grid
- **Central Ray:** not perpendicular to the grid
- **Cause:** improperly positioned x-ray tube & grid
- **Results:**
  - Grid cutoff across image
  - Underexposed
  - Light image (low OD)

2.) OFF-CENTER GRID

- Occurs when the central ray of the x-ray beam is not aligned from side to side with the center of focused grid
- Problem in focused grid
- Also called lateral decentering
- **Central Ray:** perpendicular to the grid
- **Causes:**
  - Improperly positioned x-ray tube
  - Grid is shifted laterally (lateral decentering)
- **Results:**
  - Partial grid cutoff across image
  - Underexposed
  - Light image (low OD)

3.) OFF-FOCUS GRID

- Occurs when using an SID outside of the recommended focal range
- Problem in focused grid
- **Cause:** improper focal distance
- **Effect:** grid cutoff toward edge of image
- **Proper Focal Distance:** more important with high ratio
  - **Rationale:** less positioning latitude than low ratio grid

4.) UPSIDE-DOWN GRID

- Occurs when a focused grid is place upside down on the image receptor
- Problem in focused grid
- **Cause:** improperly positioned grid
- **Effect:** severe/complete grid cutoff toward edge of image

5.) OFF-CENTER, OFF FOCUS GRID

- Most common improper grid position
- **Effect:** grid cutoff on one side of image

GRID LINES

- The images made when primary x-rays are absorbed within the grid strips
- **Visibility:** directly related to the width of the grid strips

HOLLIS E. POTTER (1920)

- He invented the moving grid

MOVING GRID

- A Potter-Bucky diaphragm or Bucky
- **Grid Used:** focused grids
- **Advantage:** minimize grid lines
- **Disadvantages:**
  - Requires bulky mechanism
    - **Effect:** subject to failure

- Increase distance between the patient & IR
  - **Effect:** unwanted increase in magnification & image blur (undetectable)
- Introduce motion into cassette-holding device
  - **Effect:** additional image blur (undetectable)

TWO BASIC TYPES OF MOVING GRID

1.) RECIPROCATING

- A moving that is motor-driven back and forth several times during x-ray exposure
- **Total Drive Distance:** approximately 2 cm

2.) OSCILLATING

- The grid oscillates in a circular fashion around grid frame
- Coming to rest after 20-30 seconds

GRID SELECTION

- **Depends of Three Interrelated Factors:**
  - kVp
  - Degree of cleanup
  - Patient dose
- **Focused Grid:** most commonly used
  - **Considerations:** must have properly adjusted
    - SID indicator
    - STD indicator
    - Collimators
- **Higher Ratio Grid:**
  - For high kVp technique
  - Increase cleanup
  - Increase patient dose
- **8:1 Grid Ratio:** used when kVp is below 90
- **Above 8:1 Grid Ratio:** used when kVp is above 90

APPROXIMATE CHANGE IN RADIOGRAPHIC TECHNIQUE FOR STANDARD GRIDS

Grid Ratio	mAs Increase
No grid	x 1
5:1	x 2
6:1	x 3
8:1	x 4
10:1 or 12:1	x 5
16:1	x 6

PATIENT DOSE

- **Moving Grid:** 15% more radiation to patient than stationary grid
- **High- kVp & High-ratio Grid:** lower patient dose than low-kVp & low-grid ratio

GRID SELECTION FACTORS

1.) Patient dose increases with increasing grid ratio
2.) High-ratio grids are used for high-kVp
3.) Patient dose at high kVp is less than that at low kVp

AIR-GAP TECHNIQUE

- An alternative to the use of radiographic grids
- **IR Distance:** 10-15 cm from the patient
- **Advantages:**
  - Reduces scatter radiation
  - Enhances image contrast
- **Disadvantages:**
  - Image magnification
  - Focal-spot blur
- **Applications:**
  - Chest radiography
    - From 180 to 300 cm SID
    - **Effects:** little magnification & sharper image
  - Cerebral angiography

☺ THE END ☺

"BOARD EXAM is a matter of PREPARATION. If you FAIL to prepare, you PREPARE to fail"

04/12/14